No. 2. — *The Chimaeroids* (*Chismopnea* Raf., 1815; *Holocephala* Müll., 1834), *especially Rhinochimaera and its Allies.* By Samuel Garman.

There are few of the marine animals that on account of structure and relationships to other forms living and extinct have as great interest for zoölogists and palaeontologists as the Chimaeroids. Their line of descent extends to Devonian times and away beyond and back to a meeting with that of the Plagiostomia near the point at which the latter separated from the bony fishes. That the line has been well traced for a long distance through the fossils only makes it the more interesting. Item after item of information relating to the group has been carefully gathered, discussed, and placed on record, but the advances among the recent have been very slow, and those among the fossils, though in some ways much more extensive, have left much to be desired. The type species of Chimaera and Callorhynchus have been known since the establishment of these genera by Linné and Gronow, in 1754. More recently other species have been added to each of them. A most important addition to the knowledge of the group dates from the capture of the types of the genus Harriotta, by the United States Fish Commission, and their description by Messrs. Goode and Bean, in 1894, and a little later another was made by the discovery of a Japanese species, by Professor Mitsukuri, in 1895, which was placed in the same genus, named but not described. The importance of the species from Japan was not recognized for some years, until Dr. Alexander Agassiz, returning from one of his explorations of the Coral Islands, saw and purchased a second specimen from a dealer in Tokyo. Dissection of this specimen supplies the reason for existence of this paper; it brings to light a number of interesting details concerning Chimaeroids, and some which pertain to other forms than that directly under consideration. The following are among the results and conclusions, brought prominently forward at this moment, that appear to be most worthy of attention.

The species, Rhinochimaera pacifica, is described and figured with details of skeletal and other anatomy.

A new genus, Rhinochimaera, is established, also a new family, Rhinochimaeridae, to contain Rhinochimaera and Harriotta, and still another new family, Callorhynchidae, to include the genus Callorhynchus.

The body of Rhinochimaera is typical of that of most Chimaeroids; the proboscis is an ancestral feature that has become much reduced in Callorhynchus and is obsolescent in Chimaera.

The rostral cartilages are articulated to the skull and are not prolongations of it, as in certain Platosomia, Raiae, or in Antacea, Sharks, on some of which the rostral cartilages resemble a tripod, but with two legs superior, unlike Chimaeroids.

The nearest approach, so far as noted, of recent Chimaeroids to Plagiostomes, as attested by brains, dorsal spines, etc., is made toward Squalus and Heterodontus of the Antacea.

The teeth of Rhinochimaera resemble the embryonic and ancestral more than those of the other recent genera of Chimaeriforms; they are cutters rather than grinders, and probably are most like those of the Myriacanths and Rhyncodonts among the fossils.

In Harriotta the tritors are grouped like the grinders of certain Placodont fishes more than those of other Chimaeroids.

The tritors originated on the horny dental plate through stress or impact, much as the molars of Placodonts and others were originated from the indurated membranes of the jaws, or their hardened papillae.

To judge from the dentition alone, the extinct Myriacanths were nearer the ancestral stem on which farther back the four-toothed forms Rhynchodus and Rhamphodus may likewise be found.

The brain of Rhinochimaera, like its rostrum, is nearer that of Callorhynchus than to that of Chimaera, reduction in the head of the last having brought the hemispheres and the olfactory lobes in contact.

The notochord of Rhinochimaera is provided with rings like that of Chimaera; it is unlike that of Callorhynchus, which shows no rings and is probably the more primitive type.

The males of living Chimaeroids are subject to a certain metamorphosis in acquiring secondary sexual characters as they become mature; a frontal tenaculum and two ventral tenacula are developed as the claspers approach functional maturity.

A more primitive form of the frontal tenaculum is that of the extinct form Squaloraia; in its inception the organ was merely a transverse fold of the skin on the forehead.

The frontal tenaculum, being a sexual character, is not to be homolo-

gized with dorsal spines, or with the illicia of the Lophioids, though treated as if of similar nature by early authorities.

The function of the tenacula below the bases of the ventral fins is somewhat like that of the series of erectile hooks on the upper sides of the pectorals of some Platosomia, Raia ocellata, for instance.

The lateral canal systems of Rhinochimaera and Harriotta are made up of pseudotubules, tubes narrowly slit outwardly; that of Callorhynchus consists of tubes, and that of Chimaera is a system of grooves.

The spiral intestine of Rhinochimaera is similar to that of the other living Chimaeroids.

The first dorsal is short, erectile, and has a spine and radials in all members of this group.

The second dorsal is long in the Chimaeridae, of medium length in the Rhinochimaeridae, and short in the Callorhynchidae.

The armature of the supracaudal fin is peculiar to Rhinochimaera.

The claspers of Rhinochimaera and Harriotta resemble one another; except in being simple, they are unlike those of Callorhynchus; in those of the Chimaeridae the cartilages are trifid.

The claspers, intromittent organs, are possessed by both Plagiostomes and Chimaeroids; the tenacula of the latter are peculiar to them.

The position of the clasper of the Chimaeroid is rather above the edge of the ventral; that of the Plagiostome is below it.

Certain peculiarities of the Chimaeroids, especially of skull and brain, are perhaps best accounted for by supposing the group to have been derived primarily from a short-snouted and short-faced form, acquisition of the long snout and the prognathous condition of the skull afterward carrying the olfactory lobes and the hemispheres forward and separating them from the balance of the brain and from one another, and in Chimaera a still later loss of the snout and shortening of the anterior part of the skull bringing the lobes and the hemispheres together into a single mass.

Rhinochimaera pacifica.

Plate 1, Fig. 1.

Hariotta pacifica Mitsukuri, 1895, Zoöl. Mag. Tokyo, VII., without description.
Rhinochimaera pacifica Garman, 1901, Proc. N. E. Zoöl. Club, II., 75.

The specimen here described is a fully developed male of about thirty-six inches in length, before a slight loss from the filamentary extremity of the tail. On account of the figure some of the details of shape need not be dwelt upon

in the text. In a general way the form is that of a Chimaera with a long proboscis from the forehead. The amount of compression in the head and body is not very great; the body cavity is included in the anterior half of the total length; the head is massive, rather longer than the abdominal portion of the body, and has a long tapering rostrum which is subtriangular in cross-section, placed pretty well up on the forehead, flattened and provided with special sensory apparatus on the lower side, depressed and slender forward, and pointed at the end; the caudal region occupies half or more of the total length, is compressed and tapers regularly to a filamentary extremity, is encroached upon by the second dorsal fin, is surmounted in part by a low rudimentary fin, the upper edge of which bears an armature, and is subtended by a longer, deeper, and unarmed subcaudal fin. The skin is soft and smooth; there are four vertical fins and two pairs; the anterior dorsal is erectile and has a strong serrated spine and distinct radials. The length of the head is more than one-fourth, the length of the caudal section is about one-half, the length of the snout is little more than one-sixth, the depth is nearly one-tenth, and the width is nearly one-fifteenth of the total length. The oral portion of the head is prominent; the mouth is similar to that of Chimaera. As in the other recent Chimaeroids, there are three pairs of the teeth, one of palatines, one of vomerines and one of mandibulars, Plate **5**, Figures 1 and 2. Mere dot-like points, to be seen under a lens, on the sharp edges of the teeth, are the only approaches to tritors; they have the appearance of the ends of small pores. By comparison of the tongue figured on Plate **12** with those on Plate **5** and Plate **13**, it will be seen that this organ attains a somewhat greater development in the present form. The eye is large and is placed on the side of the head in such position as to command views outward, forward, and upward without hindrance. On the first and the second arches there are five well-developed gillrakers, with several rudiments; they are short, hardly one-sixth as long as the eye, and are acuminate; on the third arch and the fourth all of the rakers are more or less rudimentary. This individual, being a mature male, possesses a frontal tenaculum, armed with about ten series of hooked spines, above the front edge of the orbit on the forehead. The back is nearly straight. The dorsal spine is situated above the bases of the pectorals: it is strong, has a narrow ridge in front, and is smooth on all edges with the exception of slight roughnesses on the hinder angles near the outer end, possible indications of sharp hooks on young individuals. Four rays appear in the first dorsal behind the spine, and a low membrane connects this fin with the second dorsal, which last rises gradually to less than half the height of the first and terminates abruptly more than twice the length of the eye forward from the origin of the upper fin of the tail. The upper caudal fin rises gradually, and, descending even more so, terminates more than twice the length of the orbit forward of the end of the tail, on this specimen. On the upper edge of this fin, which is somewhat rudimentary, there is a peculiar arrangement of small spines, Plate **4**, Figure 2; a pair of larger ones are placed side by side and directed laterally, and behind each pair, between it and the next, there is a couple (1–3) of smaller spines placed longi-

tudinally and pointing upward, forward, or backward. This armature continues to within a short distance in front of the end of the tail, and behind its point of disappearance there is a low ridge to the extremity. The subcaudal fin is much deeper than the supracaudal; it originates below the termination of the second dorsal, rises gradually, becomes deepest in the anterior half of the length, then slowly tapers to the caudal filament. The pectoral fins are long, more than two and one-half times as long as wide, and when extended the sharp outer angle reaches to the bases of the ventrals. The length of the ventral fin is about equal to the height of the first dorsal and the width is less than half of the length: the claspers are simple, slender, nearly four times as long as the eye, subround in trans-section, very muscular near the base, enlarged into an oblong rounded spine-covered bulb at the extremity, and jointed so as to be turned directly forward, Plate 3, Figures 1, 4 and 5; each ventral tenaculum has three strong hooks on its inner edge. There is no distinct anal fin.

On the sides and the lower surfaces the color is a light olivaceous or plumbeous more or less silvered; toward the back and on the tail it is more brown; the fins are darker to blackish outward.

Total length, 35.5; snout, 6.5; snout to dorsal spine, 10.8; snout to second dorsal fin, 15.4; snout to upper caudal armature, 24.4; snout to vent, 17.2; depth, 3.5; length of pectoral fin, 6 5; length of ventral fin, 3 5: snout to anal, 20; snout to pectoral fin, 10.3; snout to eye, 8.3; length of orbit, 0.8; length of dorsal spine, 3.6; length of clasper, 3.1; width of gill aperture, 1 1: width of body or head, 2.4; length of cephalic tenaculum, 0.6; length of head, 9.5; depth of body at axil of ventral fin, 2.2; width above axil of ventral fin, 1.1: and length of caudal section (probably after a slight loss), 17.5 inches.

Specimen described from Tokyo, Japan. Other specimens are said to have been purchased in the same market that were caught near by, in water of two hundred fathoms or more in depth, off Misaki.

Lateral Canal System, Plate 1, Figure 1; Plate 2; Plate 4, Figure 3.

The structures and functions of these canals are similar in the Chimaeroids and the Plagiostomia. The excessive differentiations of structure and the complexities of function obtaining on some of the deep-sea bony fishes do not occur on either of them. In the distribution of the canals, however, there are certain peculiarities in all the members of the group that distinguish the Chimaeroids from both Plagiostomes and bony fishes. A description of the system on Rhinochimaera applies fairly well to all the genera of its kindred, for even in the strange form of Callorhynchus one has but to apply the foliation of the snout to the lower side of the rostrum to make the similarity at once apparent. For comparisons and for nomenclature see this Bulletin, Vol. XVII., No. 2, Garman, 1888, On the Lateral Canal System of the Plagiostomia and Holocephala, Plates I. to LIII., and Mem. Mus. Comp. Zoöl., Vol. XXIV., Garman, 1899, Deep Sea Fishes, Plates LXIX. to LXXXIV. On the Chimaeroid the aural branch of the system, which crosses the back of the head, lies in front of the orbital,

which latter passes down behind the eye, and connects directly with the cranial; this places the short occipital behind the aural, and consequently the orbital does not meet the cranial. On Plagiostomes and on bony fishes the occipital is in front of the aural, and the orbital meets the cranial at some distance in front of the aural. In one case the occipital can be regarded as a portion of the lateral line, in the others it must be considered as a continuation of the cranial branch. On Chimaeroids again, the mouth being forward from the eye, the angular branch passes down and forward from the orbital to meet the narial, but on Plagiostomia having the mouth backward from the eye the angular passes backward. In the Rhinochimaeridae the canals have the appearance of tubes that have been longitudinally slit on the outer side, Plate **4**, Figure 3; they are thus intermediates between the more open grooves of the Chimaeridae, and the tubes of the Callorhynchidae. As is seen on Rhinochimaera, Plate **1**, Figure 1, the jugular meets the orbital, and the angular descends from the orbital and passes downward and toward the front to meet the nasal and the oral: the same is true in Harriotta, Plate **2**, Figure 4. In Chimaera the oral meets the angular, Lat. Canal Syst., Plate II., Figures 3 and 4, but on Callorhynchus it starts from the orbital, l. c., Plates III. and IV., Figure 1. On both Rhinochimaeridae and Callorhynchidae the jugular starts from the orbital; on Chimaeridae it starts either from the angular or the orbital. On the individual from which the description of Rhinochimaera is taken, the aural is not continuous across the head, but is in two parts, which pass one another and overlap for some distance. Plate **2**, Figure 1: the cranials and rostrals pass from the junction of aurals and occipitals forward to the end of the snout, bending toward one another between the eyes; the subrostral lies at the side of the snout and meets the orbital below the middle of the orbit; the occipital passes down and backward from the aural; the orbital goes down and forward from the occipital; and the angular goes down, then bends forward to the oral and the nasal. The jugular meets the orbital, and, like the oral, is more or less broken and disconnected behind the symphysis. On this specimen the narials of the two sides are continuous across the lower side of the snout, forming the only complete connection, except the neural, between the system of the right side and that of the left. On specimens of Harriotta the narials appeared somewhat broken at this point, orals and angulars also were broken, but the aurals were undivided, Plate **2**, Figures 3 and 5. On both Rhinochimaera and Harriotta the line makes some descent backward from aural and cranial to orbital and thence proceeds nearly straight back to a point below the origin of the supracaudal fin, where it turns toward the upper edge of the subcaudal fin and continues along the lower edge of the side on the muscular portion to the end of the tail. The close general correspondence of the lateral systems of these genera is very evident if the figures of Rhinochimaera pacifica, Plate **1**, Figure 1, and Plate **2**, Figures 1 and 2, are placed side by side with those of Harriotta raleighana, Plate **2**, Figures 3 to 5.

The Claspers, Plate 3, Figures 1, 4, 5.

The claspers of Rhinochimaera are similar in construction to those of Callorhynchus; they differ greatly from those of Chimaera. They have the appearance of being formed of a narrow strip of cartilage rolled into a tube, then twisted so that the joined edges, indicated externally by a shallow groove, are given a complete turn in the length of each clasper. In the distal half each is round, hard, and slender; proximally each is much thickened by the strong muscles that surround its base and include the receptaculum, the opening to which is hardly visible on the outside. At the free end, the tube from the receptaculum opens in the cleft extending from the interior of a small, fleshy, spine-covered bulb. As the claspers lie at rest, the clefts open outward from one another; but when in function the claspers are turned down and forward with a slight rolling motion, Plate 3, Figure 4, making the clefts to open inward, more toward one another, and the spine-covered surfaces to be carried outward so as not to come in contact. The spines at the extremities are erectile and hook toward the bases of the organs, thus forming effective holders. Turning the claspers down and forward from the body appears to open the mouths of the receptacula and bring them near the openings of the spermatic ducts. For comparison with those of Rhinochimaera the intromittent organs of a skate, Raia laevis, are figured on Plate 4, Figure 5; they are turned toward the head as in function, without indicating the peculiar structures of the cartilages near the outer ends. The position of the clasper with regard to the ventral fin may be a matter of no great importance, yet it adds to the number of peculiarities distinguishing recent Chimaeroids from the Plagiostomes. The clasper of the Chimaeroid, Plate 3, Figures 1 and 2, occupies a position above the edge of the ventral fin, in a measure between the fin and the body; that of the Plagiostome (Plate 3, Figure 3, a young specimen of Carcharinus terraenovae) lies below the edge of the fin, which extends between the clasper and the body.

The Skull, Plate 1, Fig. 2.

In the skull of Rhinochimaera pacifica there is little or no departure from the general type of Chimaeroid skull. The shapes as outlined, either from above, below, or from the side, may be described in similar terms, and the minor differences are not much greater than are to be seen in the different species of Chimaerae, or even than those obtaining in the different stages of an individual of a species of Callorhynchus. The parietal region is broader than that of Chimaera monstrosa, and narrower than that of Callorhynchus callorhynchus: the frontal region is thicker, wider, and rounder, and does not form a blade-like crest as in Callorhynchus. The facial portion, oral and olfactory section, is more produced than that of Chimaera monstrosa; in this respect it more resembles that of Callorhynchus callorhynchus, in which the narial portion of the skull is much farther forward from the eye than in Chimaera monstrosa, Plate 11. In the young of Callorhynchus callorhynchus,

Plate **10**, and in the young of other Chimaeroids the facial region of the skull is shorter than in the adult.

Whether a distinct rostral prolongation is developed or not, the rostral cartilages are similar in all the genera of recent Chimaeroids. The upper rostral cartilage of Rhinochimaera rests on the frontal crest, about midway from the orbital to the narial section, and has a more robust development than on any other of the known Chimaeroids, Plate **1**, Figure 2. On Chimaera colliei the point of attachment of this cartilage is about the same, but on Chimaera monstrosa, Plate **11**, it is higher on the forehead, and on Callorhynchus callorhynchus it is much nearer the nasal sacs. Though Plate **10** was drawn from a very young specimen, which had not attained the great facial prolongation of individuals of the same species at greater age, it shows the lower rostral cartilages with a proportional development approaching that seen in Rhinochimaera, Plate **1**. As shown on Plate **11**, in Chimaera monstrosa, and in other species of the same genus, the lower or subrostral cartilages are much dwarfed in size, as also is the case with the upper or suprarostral, though in much less degree. The fact that these cartilages are present and so well developed in the species of Chimaera, in the absence of a rostrum, suggests that a rostrum existed in ancestral forms and has become obsolete. The three rostral cartilages are present, in varying degrees of perfection, on each genus of the Chimaeroids. The bases of these cartilages are attached to the skull by ligament in such a way as to admit of considerable movement of the distal extremities up and down. On Chimaera monstrosa, Plate **11**, the suprarostral cartilage presents the appearance of having originally been attached near the nasal capsules, as in Callorhynchus, and of having the basal portion, for a short distance, brought back against and fused with the frontal region of the skull; the ligamentous attachment, however, is at the base of the free portion.

The labial cartilages, present on all the genera, are the same in numbers and positions, but vary greatly in size. They have been worked out in Chimaera and Callorhynchus by Müller. On Rhinochimaera the lower labial cartilages — that is, the larger ones (called by Müller the unterer unpaarer Lippenknorpel in Callorhynchus, but actually paired in this genus as in the other genera) — are smaller than those of Callorhynchus callorhynchus, Plate **10**, and larger than those of Chimaera monstrosa, Plate **11**, said to be absent by Müller. By some authorities the remnants of the intermaxillaries and the maxillaries are to be found in the superior labial cartilages. In all of the genera examined there is a pair of lower labial cartilages. This pair is closely bound together in large specimens of species of Callorhynchus, but in young individuals the two are distinct, and in very young ones of Callorhynchus callorhynchus there appears to be an additional pair of slender bars of cartilage crossing immediately in front of the large ones. These are distinctly shown on Plate **10**; on later stages they have apparently fused with the larger ones behind them. The excessive development of the chin cartilages, the unterer unpaarer Lippenknorpel of Müller, in Callorhynchus is no doubt connected with feeding habits which necessitate grubbing or picking food off the rocks or out of the sands.

Branchial Skeleton, Plates **12**, **13**.

In general the branchial skeleton of Chimaeroids does not reach so great a degree of perfection as that of the Plagiostome. This is especially evident in the basibranchials, copulae, which in all the species of Chimaeroids are more or less undeveloped, some of them being mere lumps of cartilage in the tissues attached but remotely to the hypo- and cerato-branchials. A marked contrast in these respects is to be seen on comparison of the species figured on Plates **12** and **13** with such a shark as Chlamydoselachus anguineus, one of the lowest of its order, possessing the greatest degree of perfection in the branchial skeleton, in which basibranchials and hypobranchials are fully developed and intimately connected. On the other hand, the epibranchials of Chimaeroids are commonly better developed than those of the Plagiostomia.

The branchial cartilages of Rhinochimaera pacifica, Plate **12**, are typical of its entire group. Such differences as there are lie mainly in the inferior connections among the copulae. With exception of the hindmost one, the basibranchial copulae are more remotely connected with the hypobranchials than is the case in the sharks; they are rounded lumps or disks of cartilage which do not form close articulations. In the branchial cartilages of this species, Plate **12**, the three copulae between the first basibranchial and the fifth are represented by two pairs of small lumps of cartilage and a larger odd one, the connections of all of which are ligamentous and remote. The glossohyal is wedge-shaped and does not entirely separate the basihyals, as in case of Callorhynchus callorhynchus, Plate **13**, Figure 3; it differs also from that species in that it is produced forward into the tongue. The hindmost copula is broad anteriorly; in the posterior third it tapers to a sharp point; it is shaped much like that of species of Chimaera, Plate **13**, Figures 1 and 2, and is not so narrow and slender as that of Callorhynchus on the same plate, Figure 3. Apparently there is considerable individual variation to be considered in connection with all the Chimaeroids, especially in regard to the basibranchials. The first two and the last one of the copulae appear to be regularly present, but between these there are a couple which in cases are present as pairs, in others as single lumps. Instead of the single copular lumps present in Callorhynchus callorhynchus, Rhinochimaera pacifica has two pairs, Chimaera monstrosa has a pair and a single large shield preceded by a small pair, and Chimaera colliei has a pair and a single large shield followed by a pair, while the shield or lump preceding the hindmost has a pair of small cartilages in front of it and another pair behind it, Plate **13**, Figure 2. Among other variations obtaining among the species, that of the glossohyal is noted in connection with the tongue, and those of the epibranchials from elongate and narrow in Rhinochimaera, Plate **12**, Figure 2, to short and broad in Callorhynchus callorhynchus, Plate **13**, Figure 3, are readily to be seen on examination of the mentioned figures.

Tongue, Plates **12** and **13**.

The tongue of Rhinochimaera is larger than that of either of the other species dissected; it is prominent, free from the floor of the mouth, and is well supported by a forward prolongation of the glossohyal cartilage. At the forward extremity it is truncate; the upper surfaces are covered with papillae, Plate **12**. In both of the species of Chimaera dissected the tongue is seen to be much smaller, sharper in front, and to have much less of the glossohyal within it, Plate **13**, Figures 1 and 2. The tongue of Callorhynchus callorhynchus, Plate **13**, Figure 3, is greatly reduced or quite rudimentary, and the glossohyal is not produced into it as in the other forms described. From the shape of the tongue of Harriotta raleighana, it is evident that the glossohyal is produced into it; the skin of the organ is peculiarly thickened and folded on its upper surface, Plate **5**, Figure 5, a consequence probably of rough contact and severe pressure by the hard portions of the food that has established the tritors on the teeth. The tongue of Harriotta is markedly different on the surface from that of either of the other genera, as is sufficiently obvious on comparison with the tongues figured on Plates **12** and **13**, all of which are furnished with numerous papillae.

Teeth, Plates **5**, **6**, **7**.

In all the known recent Chimaeroids the individual possesses three pairs of teeth, vomerines, palatines, and mandibulars, one pair of each; that is, two pairs of upper and one pair of lower teeth. Some of the fossil forms appear to have had a greater number, and some of the earliest of the extinct types apparently had a single pair of lower opposed to a single pair of upper teeth. Rhynchodus of the Corniferous and Hamilton limestones, Devonian, described by Newberry from Ohio, is said to be limited to the two pairs, vomerines and mandibulars, so also is Rhamphodus of Jaekel, from the Upper Devonian. These genera are of some interest in connection with this writing because their tooth-characters are in certain respects similar to those of Rhinochimaera, which among recent species possesses the most primitive features of dentition. Of living forms the resemblances in the outlines of the teeth are closer than in their details of structure. While the differences in these last are excessive, they are so distributed among the genera most closely allied in regard to other peculiarities as to prevent use in distinguishing higher groups. This is well illustrated by the teeth of Rhinochimaera and Harriotta, members of a single family, Plate **5**, — instances respectively of the least differentiated and the most specialized in dental structures. An abundance of fossil Chimaeroid teeth suggests that they may have been shed at times by individuals as in Plagiostomia. While a periodical shedding of teeth might be expected from what obtains in other forms, we have as yet no evidence of its existence. The worn condition of the teeth in all specimens at hand points rather toward a continuous growth

from the nourishing tissues and a continuous grinding away on the side toward the mouth cavity.

The mouth of Rhinochimaera is narrower and more pointed than that of its fellows, probably in these respects approaching that of Rhynchodus, or of Rhamphodus, consequently its teeth are narrower and more elongate, Plate **5**, Figures 1 and 2. Altogether the mouth resembles in a measure the beak of a bird of prey; the teeth pass one another like the edges of a pair of shears and in front the vomerines are turned downward in a sharp hook. As the teeth are used entirely for cutting and holding and not for crushing, the stress comes on the sharp edges. The unassisted eye may hardly detect the existence of tritors, but with a lens, where the edges have been somewhat worn away, a series of the extremities of minute calcigerous tubes or pores is to be recognized. The dental plates are thin; in appearance they recall the horny fin rays, though they are not fibrous and are much harder and more brittle. The vomerines are small, convex outwardly, concave inwardly, in contact forward, hooked downward in front of the lower jaws, and feebly notched on the lateral cutting edge by contact with the mandibulars. The palatines are not in contact on the median line of the mouth; each of the pair is long and narrow, concave on the lower surface, blunt on the inner angle, slender and acute posteriorly, straight on the cutting edge except at the forward extremity where it curves upward, and but little bent upward on the inner edge. The mandibulars are longer, more slender, and more pointed than the palatines; they are concave on their upper surfaces, rounded instead of angled inwardly, slightly in contact at the symphysis, very little bent downward at the inner edges, and straight on the cutting edges except when curving down and inward below the vomerines. The only tritoral areas on these teeth are on the cutting edges. Probably the teeth of Rhinochimaera do not vary greatly from the type possessed by the ancestral Chimaeroid, and no doubt the changes undergone in the teeth from very young to adult stages are comparatively slight. The indicated food of this Chimaeroid is crustacean and other life, of considerable depths of the ocean, in which the skeletons have no great degree of hardness.

Harriotta, in most respects the nearest ally of Rhinochimaera, differs radically in regard to the teeth, Plate **5**, Figures 3, 4, 6–9. The dental plates are similar in shape and alike in number, but the tritors, even though they owe their existence to the common causes, stress and impact without perceptible differences in regard to exertion or reception, differ in arrangement from those of any other known Chimaeroid either fossil or recent. The mouth being wider in this genus than in Rhinochimaera and the function depending on the side of the tooth, rather than on the edge, the teeth are broader and much less sharpened at their extremities. The vomerines are of moderate size, somewhat broad, convex outward, concave inward, slightly hooked down in front of the mandibulars, and bear a marginal series of small tritors about nine in number. They are in contact forward, and rather widely separated backward on the median line. The palatines are broad, broadly rounded in front and at the inner angle, more or less sharp posteriorly, and bear more or

less of a prominence, due to the median series of tritors, on the hinder margin. The tritors with some irregularity are distributed in four rows: an outer series at the edge of the tooth of about six rounded tritors, an inner series of about three near the front end, a median series of several parallel with the inner, and a posterior series of about nine broad, short, closely placed tritors extending from the hind margin forward over more than half of the tooth and to some extent resembling the dental series of certain Myliobatidae. The mandibulars are pointed at each end and convexly curved on both outer and inner margins; they bear an outer series of small rounded tritors anteriorly, along about two-thirds of the edge of the tooth, and a median or posterior series of broad, short, closely packed tritors in the hinder three-fifths of the tooth, extending to the hind margin, but not to the posterior extremity. The description immediately foregoing is taken from a specimen that had almost reached maturity, and may be said to fairly represent conditions in an adult, Plate **5**, Figures 3 and 4. The appearance of the teeth in a half-grown specimen are indicated on Plate **5**, Figures 6 and 7. Of such immature specimens the teeth are farther apart and on each tooth the angles are less developed. The tritors also are farther apart and much smaller, some of the hindmost of the wide ones of the inner series being very faintly indicated or altogether absent. Each of the teeth at this stage may be described as shorter, broader, and less angular than the corresponding tooth of the adult. In quite young specimens, such as that of which the teeth are figured on the same plate, Figures 8 and 9, the teeth are less broad and more angular and tritors have not appeared. This in all likelihood represents the condition obtaining in the adult of some ancestor; and this stage is nearer to the permanent type in Rhinochimaera. While there are no tritors on these teeth the positions they finally occupy are already indicated by slight ridges or swellings. A still earlier stage would probably bear teeth on which these ridges would not be developed.

The teeth of very young Callorhynchidae, Plate **6**, Figures 3 and 4, before the tritors appear, are similar to those of a like stage in the Rhinochimaeridae, as represented by Harriotta, Plate **5**, Figures 8 and 9. In later stages the tritors appear on the ridges of palatines and mandibulars and on the cutting edges of the vomerines. This condition appears to be retained by the adult in the type here identified with Callorhynchus smythii Benn., of which the teeth are shown on Plate **6**, Figures 1 and 2. In the other species of the genus, however, the hinder portions of the tritors of the palatine teeth enlarge and fuse, while the forward portions remain as two prongs that may apparently become less extensive toward the front; at the same time the tritor of each mandibular tooth shortens and broadens until in cases somewhat angular or nearly round, as in Callorhynchus milii, Plate **7**, Figures 7 and 8. If in addition to the individual variations those shown to occur in the five species of this genus at hand are also considered, we get a hint of what may be expected among other genera, recent or extinct. Teeth from the various stages of individuals, or of the different species detached and described, as is necessarily done with fossils, might readily lead to multiplication of synonyms for both

species and genera. Three of the known living species are reported from the southwestern coasts of South America; the other two are from Tasmania and the Cape of Good Hope respectively. The younger stages of all are similar. Callorhynchus callorhynchus, Plate 7, Figures 7 to 9, is the species most widely known; in it the tritor of each palatine tooth occupies the greater part of the entire length of the dental plate and sends forward two prongs, the inner of the two being the longer. C. smythii, Plate 6, Figures 1 to 4, as already mentioned, has two distinct parallel tritors on each of the palatine teeth. Both of these forms occur at Valparaiso and Talcahuano. C. tritoris is a new species from the Mejillones; one of its palatines and the vomerines are drawn on Plate 6, Figure 9, where the tritor of the first is seen to be placed far back on the tooth, to be broader than long and hardly notched anteriorly. In C. milii, Plate 6, Figures 7 and 8, the prongs are short; and the tritors have a considerable forward extension on the palatine teeth, while the mandibular tritor is short, rounded, or oblong, and like those of the palatines situated near the posterior edge of the tooth. This is the Tasmanian species first named, described, and figured by Bory, 1823, and later described by Richardson, 1841, under the name C. tasmanius. Callorhynchus capensis, Plate 6, Figures 5 and 6, is marked by very slender and sharp forward extensions of the tritors on both palatine and mandibular teeth; these prongs are elongate and tapering, and the hinder portion of the tritor on the palatine is comparatively short, but on the mandibular teeth the posterior swollen portion of the tritor appears to be longer than that of the tooth above it. This species was described by Duméril, 1865, from specimens secured at the Cape of Good Hope; the figures cited above were drawn from an individual sent by E. L. Layard, Esq., from the same locality. Interest in C. capensis is heightened by the fact that traces of its existence have been found in Cretaceous formations and in a locality which greatly widens its distribution. For the species described by Newton, 1876, in the Quarterly Journal of the Geological Society, p. 326, Vol. 3, and figured and described by the same author, 1878, in the Memoirs of the Geological Survey of the United Kingdom, IV., p. 41, Plate XII., Figures 11 and 12, under the name Callorhynchus hectori, from a fossil palatine tooth found at Amuri Bluff, New Zealand, in a fine conglomerate, believed to be of the age of the Lower Greensand, of the Cretaceous, is not to be separated from C. capensis by any of the characters at present known. This is the earliest positive evidence of the existence of a species of now living Chimaeroid.

The teeth of Chimaerae are more differentiated than those of any other genus of the group. Judging from the dentition, the evolution of Chimaera, as in the reduction of the rostrum, would appear to have gone a stage farther than that of the species of Callorhynchus, and in doing this to have acquired the peculiar laminated structure and the palatine and mandibular tritors on the forward edges of the teeth. The ridges on the inner sides of these teeth may be looked upon as remains of tritors, similar to those of Callorhynchus smythii, Plate 6, Figures 1 and 2. If the rise of Chimaera were to be traced, there would probably be found among its ancestors some with teeth like those of the

very young Callorhynchi, and others of a later period in which tritors, like those of Callorhynchus smythii, were present on the sides of the teeth, and yet others, still later, in which by change of feeding habits the impact had been changed to the front edges of the palatine and the mandibular teeth, where the stress or impact is generally exerted, and where tritors now are in all except very early stages of Chimaera. No better way at present suggests itself to account for the differences in dental structure found in Chimaera and Callorhynchus. On Plate **7**, Figures 1 to 3, the much-worn teeth of an old individual of Chimaera monstrosa are drawn. If the palatine and the mandibular teeth of this species are compared with the same teeth of Callorhynchus smythii, or of the very young of the other species of that genus, or even of the very young of Harriotta, it will be seen that the two lateral ridges of each palatine and the single lateral ridge of each mandibular are in the same positions, but in the later stages of individuals of Chimaera the impact is applied to the forward extremities of the ridges, and in the other genera mentioned it is exerted on their sides. Yet if the account of the dentition of Chimaera is carried no further it will be incomplete and misleading, for as the anterior edges and tritors of the palatine and mandibular plates are ground away by use in aged individuals, the impact is more and more applied to the inner sides of these plates, farther and farther backward. Consequently tritors develop, later in the lives of such individuals, on the sides of calcigerous tubes the extremities of which were the tritors of earlier stages. On the teeth, of a specimen of Chimaera monstrosa more than thirty inches in length, shown on Plate **7**, Figures 1–3, the tritors of the forward edges are the only ones that appear; the ridges of the inner sides are present, but evidently they had not served as grinders and they bear no tritors. On old individuals of Chimaera colliei the tritors of these ridges are prominent and more swollen than those of Callorhynchus smythii, Plate **6**, Figures 1 and 2, and possibly in this or other species of Chimaera they may with greater use become much expanded, or even may become confluent somewhat as in most species of Callorhynchus.

The Viscera. Plate **1**, Figure 2; Plate **4**, Figure 4; Plates **8** and **9**.

The stomach and the inside walls of the body cavity of Rhinochimaera pacifica are blackish; behind the stomach the intestines are lighter in color. The alimentary canal is but little longer than the abdominal cavity; the extent of the difference in the two lengths is indicated in the short transverse portion of the valvular section of the intestine in Plate **1**, Figure **2**. The distinctions between the stomach and the intestine are not particularly well marked, though the walls of the former are darker and are provided on the inside with longitudinal folds or striae, less noticeable when distended, which disappear at the pylorus. The intestine properly so called may be divided into two sections; a longer one containing the first turn of the spiral fold, which originates close behind the stomach at the point of the entrance of the bile duct and as a mere fold of the inner membranes, attached to the wall, gradually makes the turn as

it extends backward to the first valve; and a shorter one beginning at the valve and containing two other valvular constrictions which respectively end the second and the third turns, included between the first valve and the third. On Plate **8**, the intestine is slit open from the pyloric end of the stomach to the vent to show the long, spiral fold, the three muscular and valvular constrictions, and the two short spirals. The portion of the intestine occupied by the longest spiral is more than twice as long as that occupied by the two short ones. The diagrammatic figure 4 of Plate **4**, by means of a dotted line, traces the course taken by the food from the pylorus to the cloaca. The intestines of Callorhynchus callorhynchus, Plate **10**, are in most respects similar to those of Rhinochimaera. The numerous points of resemblance common to those of Chimaera are quite as readily seen. Professor T. J. Parker, 1880, gives a good figure of the spiral folds of Chimaera monstrosa, and describes this portion of the canal in these words, "I found a valve of only three and a half turns, remarkable from the fact that the attached edge did not form a regular spiral, but for a part of its course (namely, during the first turn) formed a slightly sinuous antero-posterior line. In consequence of this, the second compartment of the intestine was fully half as long again as the bursa entiana."

The pancreas of Rhinochimaera is small and elongate; in Figure 2 of Plate **1**, it lies above the intestine immediately behind the left lobe of the liver. As it appeared in the specimen, it was bent backward upon itself, though it may be that normally it is nearly straight. Apparently the spleen is closely bound with it. Above the pancreas, in the figure, and somewhat forward, lies the left testicle, from which the seminal tubes are traced back to the seminal vesicle immediately below the enlarged and lobed hinder extremity of the kidney. The reticulated seminal vesicle, the lobulated kidney, the disk-like testicle, and the complex of seminal ducts are shown more distinctly on Plate **8**. A lower view of these organs appears on Plate **9**, Figure 2, in which the reticulation of the vesicle is not seen.

The liver is drawn in Figure 1 of Plate **9**. It has three lobes, the right one of which is much the longer and is notched at the tip. The gall bladder lies at the right side of the stomach and its duct enters the intestine close behind the stomach at the forward extremity of the spiral fold.

In the bulbus of the heart, Plate **9**, Figure 3, there are two rows of valves, the anterior of which contains three valves, the posterior four, Plate **9**, Figure 4.

Generally the visceral features of Rhinochimaera are in close correspondence with those of the other genera of the group. And this is quite as true of the internal sexual organs as of other internal organs, contrary to what might perhaps have been expected from the great external differences in the claspers. To fully establish this, one has but to compare the present figures of Rhinochimaera with those of the sexual organs of Chimaera monstrosa published by Hyrtl, 1854.

The Brain, Plates **14**, **15**.

The brain of recent Chimaeroids is crowded together posteriorly. The optic and inferior lobes are close to the medulla oblongata and are below the cerebellum. The hemispheres are remote from the optic and inferior lobes, and the connections with them are slender and nerve-like. This shape of the brain, the massing that has taken place backward with the remoteness that obtains forward, is characteristic of the group, so far as known living genera are concerned. A similar crowding of parts of the brain is common among Plagiostomes, but the wide separation of the hemispheres from the optic lobes is peculiar to Chimaeroids. In some genera of the latter the olfactory bulbs are distant from the hemispheres, so also in particular Plagiostomia, but in one genus each hemisphere is closely connected with an olfactory bulb. In these cases either remoteness or the absence of separation of the olfactories serves to distinguish the genera.

The brain of Rhinochimaera pacifica, Plate **14**, from the medulla oblongata forward to the optic lobes differs comparatively little from that of its allies. The posterior mass is similar in shape and in the positions of its component parts. Compared with Chimaera colliei, Plate **15**, Figures 1 and 2, or Callorhynchus milii, Figures 4 and 5 of the same plate, the brain of the present specimen is somewhat smaller in the cerebellum, which does not cover the optic lobes so completely as in the other cases: this deficiency in size, however, may be a feature of the individual and not a character of the species. The nerve-like connections with the hemispheres are more slender in Rhinochimaera than is the case in the other genera. In the distance between hemispheres and olfactory bulbs Rhinochimaera pacifica agrees with Callorhynchus milii, Plate **15**, Figures 4 and 5, though the connections are even more slender than in the latter species and the olfactory bulbs are smaller. Between the hemispheres and the olfactory bulbs in Rhinochimaera the distance is about twice that between the hemispheres and the optic lobes; in Chimaera colliei the distance between olfactories and hemispheres has vanished, while that between the latter and the optic lobes remains. Similar comparisons may be made with the brain of Chimaera monstrosa, which has been worked out by Dr. Wilder and others.

Miscellaneous.

The first mention of the species described above, and a full-grown male of which is figured on Plate **1**, in one-third of its life size, was published by Professor K. Mitsukuri in the Tokyo "Zoölogical Magazine," No. 80, Vol. VII., June, 1895, with an outline sketch on Plate 16 of the same volume. The more important portion of this notice, containing all the description, is reprinted below. By some mistake the outlines were said to be those of a male; they are evidently those of a female. Professor Mitsukuri's remarks are given in his own words: —

"The specimen (male) was bought in the Tōkyō market and is marked as from *Kurihama, Province of Sagami;* there can be no doubt that fishermen of that village caught it in the deep waters (two hundred fathoms or more) contiguous to Misaki. Its unique characters had long been noted by us.

"Unfortunately, I am not yet in possession of the original description of *Hariotta raleighana* by Messrs. Goode and Bean. But the short description, 'the extremely elongate muzzle and the feeble claspers' as well as the comparison of the two figures leave no doubt in my own mind that the two individuals figured belong to the same genus.

"There can also be very little question that they belong to different species. (1) The general shape of the body, (2) the shape and size of the pectoral and ventral fins, (3) the point to which these fins reach when laid back, (4) the shape and disposition of the dorsal fins, (5) distribution of the lateral-line sense-system all seem to point to the specific distinction of the Atlantic and Pacific specimens. The name *Hariotta pacifica* will be most appropriate to the Japanese species."

It would be a matter of some difficulty from this notice, or from the outlines accompanying it, to make a satisfactory identification; it was only by comparison with the type that it might be done. No other description had been published when the specimen of which the present writing treats was brought by Dr. Agassiz from Tokyo. This specimen was dissected from one side and drawings and descriptions were made from the preparations. In the second volume of the Proceedings of the New England Zoölogical Club, page 75, a short preliminary to the present paper was published, in 1901, under the title "Genera and Families of the Chimaeroids," in which it was shown that Professor Mitsukuri's species did not belong to the genus Harriotta, known from the Atlantic, that it represented a new genus, which was then characterized and named Rhinochimaera, and that it with Harriotta constituted a new family, the Rhinochimaeridae, of equal rank with the Chimaeridae and the Callorhynchidae, the last also a new family. The genera and the families were briefly characterized in the preliminary; the characterizations, of greater length and slightly modified by the anatomical studies, are repeated in the present paper. One question raised by the subsequent studies relates to the presence or absence of tritors in Rhinochimaera. On teeth the cutting edges of which have not been worn with hard usage no tritors are visible; but if the extremities of the minute calcigerous tubes to be seen with a lens on the cutting edges of worn teeth are to be accepted as tritors, it is incorrect to say Rhinochimaera has no tritors. Besides the possession of several series of molar-like tritors, the structure of the proboscis in Harriotta, depressed instead of compressed, is a very patent distinction. It was stated in the preliminary that the frontal tenaculum is present on the males of Harriotta, as on males of Rhinochimaera, Chimaera, and Callorhynchus, a fact which was denied in the original diagnosis of that genus. It was added that the frontal tenaculum is only acquired by the young male somewhat late in his existence, about the time he becomes sexually mature and the intromittent "claspers" have approached functional maturity, the advent of the tenaculum coinciding nearly with the beginning of

its period of utility in the congress of the sexes. This was in relation to all the genera of the group. It was overlooked at the time that Günther, in 1887, had reached a similar conclusion in regard to Chimaera. The following is a repetition of his statement.

"The development of the prehensile organ on the upper part of the snout, which is peculiar to the male sex in *Chimaera*, keeps pace with that of the claspers. This organ is visible in our youngest specimen, which evidently was hatched only a few days, as a narrow cartilage of whitish colour entirely covered by the skin, but visible through it. It has not made as great progress in the largest of the young specimens, and therefore does not seem to become detached from the head before the individual attains to sexual maturity."

"Detached from the head" in this may mean either detached from the skull, or attains to partial freedom above the skin, probably the latter.

The frontal tenaculum of the Chimaeroid male is not a modification of a fin ray, as in the Pediculati, but is an accessory sexual organ, in its inception in all probability merely a transverse fold of the skin of the forehead. If it were a modification of a fin spine or radial, it would at the first appear as such, without waiting for sexual maturity, and the embryo would be likely to exhibit traces of its evolution. The frontal tenaculum of Squaloraia, a fossil from the Lower Lias, is to be regarded as an intermediate form between the primary transverse fold and the much-differentiated frontal tenacula of the living Chimaeroids. In the fossil the base of the organ is transverse, and without the simple elongate slender distal portion would sufficiently resemble a transverse fold.

Naturally the higher groups are less clearly outlined in the fossil forms than in the recent, and the farther back attempts are made to distinguish them, along the converging lines to a common ancestry, the less definite the distinctions, until among the earlier they may not be recognized, and the more prominent and numerous the intergradations. The modern tendency of emphasizing divergent features leads to multiplication in the number of families. Woodward, 1891, in the Catalogue of Fossils in the British Museum, Vol. II., distributes the Chimaeroids in four families, Ptyctodontidae, Squaloraiidae, Myriacanthidae, and Chimaeridae. Only the last of these contained species that are now living. If the recent forms are arranged in three families, as in the present writing and in the preliminary, Rhinochimaeridae, Callorhynchidae, and Chimaeridae, the known fossil species will be distributed in five families, by leaving Chimaera pliocenica and C. javana in the Chimaeridae, and placing Callorhynchus hectori in the Callorhynchidae. Undoubtedly future studies will increase the number of families to which even the known fossils are credited. Not much can be done in comparing the recent with the extinct forms, since so little is known of the latter. In most cases the fact of existence has been established only through remnants of the dental apparatus. Of the characterized families the Ptyctodontidae are distinguished by two pairs of teeth, one above and one below, and no spines are known; the Squaloraiidae

have two pairs of teeth above and one pair below, like recent members of the group, but the dorsal spine is absent, the body is depressed, and the frontal tenaculum of the male is elongate styliform, much as the proboscis itself; and the Myriacanthidae have the dorsal spine, have dermal plates on the head, and have two pairs of teeth above and one pair and a single symphyseal tooth below.

A number of features are possessed in common by the living forms, features by which they are closely linked together and by which they are readily distinguished from their nearest allies of the Plagiostomia. The form of body or the general shape, the mandibular suspensorium, the teeth, the lateral system, the lack of shagreen, the erectile first dorsal, the frontal tenaculum, and the ventral tenacula of the males, the wide separation of hemispheres and optic lobes of the brain, the articulation of rostral cartilages; these go to distinguish the Chismopnea from the Plagiostomia. For family characters dependence is placed on the differences in regard to the proboscis, on differences in the structure of the notochord, on differences in the claspers, and on differences in the brain and in the lateral line. The generic and the specific separations are made by differences in the details of tritoral development, by the slighter variations in forms of rostra, or in the structure of claspers, by minor differences in the distribution of the lateral line, in the lengths and shapes of the fins, in colors, etc.

The partial descriptions given below are introduced not as redescriptions but as additions to knowledge of several species, rare or not easily secured, to which references have been made in this paper. The lists of genera and species recognized herein are given under the classification.

Harriotta raleighana.

Plate 2, Figs. 3-5; Plate 4, Fig. 1; Plate 5, Figs. 3-9.

Harriotta raleighana Goode and Bean, 1894, Proc. U. S. Mus., xvii. 472, Plate XIX. Figs. 1–4.

The authorities of the United States National Museum have kindly permitted examination of some of the types from which this genus and species were originally described. In consequence it is possible to add some items to the data already published. Necessarily they are limited to external features, as the specimens could not be dissected.

Specimen 35631, from the North Atlantic (Lat. 39° 12′ N.; Lon. 72° 3′ 30″ W.), at a depth of seven hundred and seven fathoms, is the original of Figs. 1 and 2 on Plate XIX. of Vol. xvii. of the Proceedings of the National Museum, 1894, or of Figs. 37 and 38 on Plate XI. of the Oceanic Ichthyology; it has the following measurements: Total length, 15.5, head, 3.5, snout to vent, 6.5, and snout to mouth, 2.5 inches. The individual is an immature male, too young to have acquired the frontal tenaculum, the ventral tenacula, or the

functional development of the claspers. Its teeth are represented by Figs. 6 and 7 on Plate 5 of the present work. In number of plates and their general outlines these teeth are somewhat like those of a young Chimaera, but in regard to the tritoral surfaces they are very different. On the palatine and the mandibular teeth there are prominent series of tritors, like small rounded molars; on each of the palatines a series appears, the next to the outer, in which the tritors from the third counting backward are broadened into transverse bars, or in which two small tritors, or more, have united into one broad one. On each palatine tooth there are four more or less complete series of the tritors, the outer two or three of which are extended farthest backward. On the outer edge of each mandibular tooth there is a series of about ten of the tritors or cusps, and from the sixth and the seventh two shorter series extend back nearly parallel with the inner edge of the tooth. The vomerine teeth resemble in outline those of Chimaera. Medially in front each hooks downward in a sharp point; laterally from the point the edge lies higher and has three rounded tritors, the hindmost of which forms the hinder edge of the tooth. The claspers are but partially developed; they are short, without spines, stout and muscular at the bases, and in the distal three fifths of the length are slender, cylindrical, and rounded. The groove is distinct to the end. The positions of the ventral tenacula are indicated by the openings, but within the tenacular cavities the organs are quite undeveloped; the spines, of course, are entirely absent. The frontal tenaculum, being of later development than the claspers, is not yet differentiated. Though there appears to be nothing on the sides of the forehead of this individual to distinguish it from a female, if looked at from above the shape of the tenaculum appears to be faintly outlined beneath the skin in its proper position. The dorsal spine has a sharp compressed keel on its front edge; it is triangular in a cross-section; each of the hinder edges turns directly outward at the side, is sharp, and is barbed by sharp teeth hooking toward the base of the spine. At each side of the postorbital space on the crown there are three or four spines in irregular series, and there are four in longitudinal series at each side of the anterior portion of the base of the second dorsal. The upper margin of the third dorsal is like the others and has no such armature as that of Rhinochimaera pacifica (Plate 4, Fig. 2).

The lateral line system resembles that figured on Plate 2, Figs. 3–5, from specimen 39415, but shows individual variation in several points. The upper rostral tract meets the lower at a short distance behind the tip of the snout; they pass into one another at each side of the rostrum. Behind the transverse band of sensory papillae or villi, on the left side of the lower surface of the snout the subrostral line extends back between the suborbital and the prenarial, but does not join with the latter like its fellow of the other side, and the prenarial does not curve out to meet it. Behind the mouth on the chin the line is broken into dashes instead of being entire and transverse; similarly on the throat the transverse line is broken more or less, and is discontinued for a short distance about the middle. Below the middle of the supracaudal fin the lateral

line suddenly drops to the lower edge of the muscular portion of the tail where it continues to the end. The line is similar in structure to that of Rhinochimaera pacifica, as figured on Plate **4**, Fig. 3; it is an open groove with closely-set ribs, which do not quite meet over the cavity. The aural portion of the line bends forward at each side from the lateral, and passing inward turns sharply back to meet its fellow in an acute angle, with the apex backward, from which a short line is extended farther backward toward the dorsal spine.

Specimen 39415 of the National Museum is a female, taken in north latitude 39° 44′ 30″ and west longitude 70° 30′ 45″ at a depth of 1081 fathoms. Its measurements are: total length, 25; length of head, 6; length of snout to mouth, 4; snout to vent, 10.5; snout to dorsal spine, 6.5; snout to anal, 14.25; snout to end of second dorsal, 14.25; length of dorsal spine, 2.75; length of pectoral fin without base, 4.5; length of ventral fin, 2; depth of body between dorsals, 2.75; width of pectoral, 2.75; width of ventral, 1.5; depth of tail, 1.4; width of proboscis, 1.1; depth of orbit, 0.56; length of orbit, 0.75; and length from snout to beginning of the upper fin on the tail, 14.9 inches. The dorsal spine has sharp retrorse denticles on both of the hinder edges, and it has longitudinal striations along its sides. It has a smooth, rather sharp ridge in front, and close behind this in a transverse section it is concave and then slightly convex. The spine has a more prominent anterior ridge and more distinct denticles than on the young, but it is stouter in proportion to the fin on the latter. The tongue is subtriangular, Plate **5**, Figure 5, and it has a peculiar structure, induced by feeding habits in connection with which its most important function may be performed in sorting out the softer tissues from the harder portions or broken shells of the prey. The teeth show a considerable advance from what obtains on 35631, as shown in Plate **5**, Figures 6 and 7. In the outlines the hindmost angles are sharper, from extension backward on the edge of the jaw, and the tritors are broader, longer, and closer together, Plate **5**, Figures 3 and 4. They have expanded until those posteriorly on the median ridge have come to resemble the dental cards of species of Myliobatis to which they suggest a similarity also in feeding habits. Possibly the tritors coalesce and their dividing lines become obliterated in greater ages, for this would be in line with the development traced through 35520 and 35631 to the present specimen; in one the tritors are merely suggested, in another they are well grown but separated, and in still another they are much enlarged and in contact, Plate **5**, Figures 3–9. Each of the vomerine teeth hooks downward in front and has 9 or 10 tritors on its cutting edge. There are three series of tritors on each palatine and but two on each mandibular tooth, Plate **5**, Figures 3 and 4; in this they differ from what obtains on the teeth of 35631, Plate **5**, Figures 6 and 7, a difference which may be due to coalescence of tritors on the older individual.

Number 35520 of the National Museum collection is a young male of about 4.1 inches in length; it was captured at a depth of 991 fathoms in north latitude 39° 37′ 45″ and west longitude 71° 18′ 45″. The specimen was secured near the time of extrusion from the eggshell, and so marks a depth at which

the eggs are laid. It is the type from which Figures 3 and 4 of Plate XIX in the Proceedings of the U. S. National Museum for 1894, and Figures 39 and 40 of the Oceanic Ichthyology were drawn. Apparently it has lost the tip of the snout and the caudal filament. The lower fin of the tail is rather indistinct anteriorly, but evidently it originates some distance farther forward than the upper. Probably the specimen was torn from the egg and mutilated in the dredge. The claspers and the tenacula are undeveloped. The parietal spines and those between the dorsals and between the second dorsal and the fin on the tail are quite prominent. They rise above the level of the head and of the dorsal fins and the dorsal spine, as these last are closely applied to the back; their function appears to be aid in escape from the eggshell and to protect the back and fins at the time and later. The teeth of this individual are figured on Plate **5**, Figures 8 and 9, in four times natural length. They exhibit slight differences in outline from those of older specimens, the principal one of which is a backward extension from the median ridges of palatines and mandibulars; a marked distinction also occurs in the apparent lack of tritors. On each of both palatines and mandibulars there is a symphyseal, a median, and an outer ridge extending to the hind edge of the tooth. Close examination discloses, even in this comparatively undeveloped stage, indications of the molar-like tritors in these ridges, in positions similar to those shown in Figures 6 and 7 of Plate **5**. In each case the inner ridge is formed by the incurved edge of the tooth. The vomerine teeth are less hooked than those on the older specimens, and the tritors are hardly visible.

Callorhynchus milii.

Plate 6, Figures 7, 8; Plate 15, Figures 4, 5.

Callorhynchus milii Bory, 1823, Dict. class. d'Hist. Nat., III., 62, pl. v.
Callorhynchus tasmanius Rich., 1841, Trans. Zoöl. Soc. Lond., III. 174.

A specimen belonging to this species, sent by Mr. W. Robertson from Hobart Town, has a total length of 10.5, a length of head of 4, a length from snout to dorsal spine or to base of pectoral of 4.25, from snout to ventral of 7.4 and to second dorsal of 7.75, a depth of body of 2.5, a length of dorsal spine of 2.75, a length of pectoral of 4, a length of base of second dorsal of 3, a distance from origin of supracaudal to end of base of anal of 0.6, and a length of caudal of 4.75 inches.

The form is compressed, and is massive about the head; seen from the side the outline is very convex and prominent above the front edge of the eye and forward for a short distance. The foliate extremity of the proboscis is broadest near the hind margin, where it is subtruncate and slightly notched. The dorsal spine is situated above the origin of the pectoral; it is compressed and sharp in front. In a trans-section it is concave immediately behind the sharp front edge, then becomes convex; the posterior edges have sharp retrorse ser-

rations. The pectoral reaches behind the origin of the second dorsal, and behind the bases of the ventrals, which last extend little farther backward than the origin of the second dorsal. Hinder margin of ventral and upper margin of second dorsal concave. Base of anal short, close to subcaudal, with which its base is united by a membrane; anal depth about equal to height of second dorsal. The bases of the anal and the subcaudal of this specimen are about a quarter of an inch apart, excepting the membrane, yet when the anal is at rest its hind border is in contact with nearly the whole anterior edge of the fin behind it. The color of the flanks is silver, of the back is light brownish, and of the fins is brown. Probably the colors vary with age and sex.

On a specimen of five and three-fourths inches in length the canals of the lateral system are not completely covered, as in the sixteen-inch individual; they are slit lengthwise, as on Rhinochimaera, but on the larger one they are closed tubes with pores leading to the interior. The pectoral in this example does not reach backward of either the origin of the second dorsal or the base of the ventral. The arrangement of the spines on this small specimen is like that on the larger one; above the hind edge of the orbit on the outer side of the cranial canal there is a short longitudinal series of two or three; just inside of this at the inner side of the canal a series begins and extends forward for about twelve spines to the front end of the interorbital space, where it crosses to meet a similar series on the other side of the crown; close to the inner sides of the posterior extremities of these series there are several spines, sometimes but one; at each side of the median line, between the dorsals, there is a longitudinal series of fourteen or fifteen spines; a similar row of fourteen spines occurs at each side of the vertebral line between second dorsal and supracaudal.

Classification.

The intention in this section is to favor that nomenclature which was first applied with approximate correctness, and to follow the rules of priority in regard to designations for the higher groups as for the lower, the appeal for fair treatment in relation to credit and recognition being admitted to be quite as worthy in the case of the larger as in that of the smaller. It does not appear entirely just to carefully credit authorities for the names of species and at the same time to disregard the claims of those who have determined the values, affinities, and classification. Besides, a general acceptance of prior names tends to abate the multiplication of synonyms.

The history of the Chimaeroids begins at a much earlier date than that of Linné, as is seen in recognizable figures of Chimaera by Clusius, 1605, Exoticorum, page 137, by Aldrovandi, 1613, De Piscibus, Lib. III., pages 402 and 403, and by others; but it is no purpose of this writing to present either a complete history, bibliography, or synonymy. A few words on the origin of each of the terms adopted will suffice.

Linné used the name Chondropterygii in the first edition of his Systema, in 1735. He divided the fishes, as he knew them, into Plagiuri, Chondropterygii,

Branchiostegi, Acanthopterygii, and Malacopterygii. The same arrangement appears in his edition of Artedi's work, 1738, and in subsequent editions of the Systema up to and including the seventh, 1748. His Chondropterygii were the genera Raia, Squalus, Acipenser, and Petromyzon.

Gronow, 1754, following Linné, recognized the horizontal-tailed fishes, the Plagiuri, and the perpendicular-tailed fishes; the latter he subdivided into those with bony-rayed fins, under the names Malacopterygii, Acanthopterygii, and Branchiostegi, and those with cartilaginous-rayed fins, the Chondropterygii, which latter included the genera Callorhynchus, Acipenser, Squalus, Raia, and Petromyzon. He had adopted most of his groups and genera from Artedi and Linné; among the additions the genus Callorhynchus is of most present interest. It is from Gronow's hand that that genus appears in the ninth edition of the Systema, 1756, without mention of Chimaera, though the latter was established by Linné in 1754, two years before the publication of that edition.

Linné dropped the name Chondropterygii in the tenth edition of the Systema, 1758, for Amphibia nantes, and there the group contains Petromyzon, Raia, Squalus, Chimaera, Lophius, and Acipenser. Callorhynchus of Gronow, 1754, was buried in Chimaera of Linné, 1754. The arrangement is similar in the twelfth edition, with addition for the worse of Balistes, Ostracion, Tetrodon, Diodon, Cyclopterus, Centriscus, Syngnathus, and Pegasus.

Gmelin, 1788, in his edition of the Systema, returned to the name Chondropterygii, and, dropping the name Amphibia nantes and taking out the genus Lophius, constitutes the group as in the tenth edition with these exceptions. The other fishes, practically the bony fishes, he placed in the groups Apodes, Jugulares, Thoracici, Abdominales, and Branchiostegi. The group Chondropterygii, with varying inclusiveness, has persisted.

Cuvier, 1798, in the Tableau Élémentaire, improved the arrangement by so much as concerns the removal of Acipenser from the Chondropterygii, and by retaining in the order Petromyzon, Raia, Squalus, and Chimaera His orders were *Les chondroptérygiens*, *Les branchiostèges*, *Les apodes*, *Les jugulaires*, *Les thorachiques*, and *Les abdominaux*. This distribution with Latin names was followed by Gravenhorst, 1807, who added to the Chondropterygii the genus Gastrobranchus of Bloch, 1795, for Myxine glutinosa of Linné, 1754.

La Cepède, 1798, divided the class into cartilaginous fishes and bony fishes. He accepted the Chondropterygii of his predecessors, but wrongly included various bony fishes, and though he carefully subdivided the groups he designated the minor divisions only by the names, apodes, jugulaires, thoracins, and abdominaux in each case, repeating these names over and over again.

Duméril, 1806, in the Zoologie Analytique, gave French names, derived from the Greek, to La Cepède's subdivisions. His first order of the cartilaginous fishes was the Trématopnés, with two families, the Cyclostomes and the Plagiostomes. His second order, and third family, he named Chismopnés: its contents were the so-called genera Baudroie, Lophie, Baliste, and Chimère. His third order, and fourth family, Eleuthéropomes, included Polyodon, Aci-

pensère, and Pégase, and his fourth and last order of the cartilaginous fishes, the Télécbranches, contained three families properly belonging to the bony fishes. It is not necessary to follow the remainder of the orders, as they are outside of the limits of this paper. It will be seen that if the bony fishes improperly included are withdrawn from the second order, the Chismopnés, the only reason for its existence lies in the genus Chimaera. Duméril gives the derivation of the word Chismopnés as "de Χισμη fente et de Πνέος respirant." If he had derived it from Χάσμα or Χάσμη and made the word Chasmatopnés or Chasmopnés, or from Σχίσμα or Σχισμή, making the word to be Schismatopnés or Schismopnés there might have been less questioning of the etymology. It is only a change of a letter in either case, but authorities differ as to whether a correction should be applied.

Rafinesque, 1815, also lost sight of the limits between the cartilaginous and the bony fishes. He took Duméril's third order for his own sixth, and latinized the French name Chismopnés in the form Chismopnea. He placed in this order the family Branchismea, with three subfamilies, the Chimeria, the Balistia, and the Lophidia, and the family Meiopteria, with two subfamilies of eels, the Echelia and the Chlopsidia. All of this order except the Chimeria belonged among the bony fishes. His seventh order, the Tremapnea, was with considerable additions Duméril's first, the Trématopnés. Rafinesque put into this order (1) the Ophictia, consisting of three subfamilies of eels, (2) the Plagiostomia, Duméril's Plagiostomes, with two subfamilies, the Antacea, Sharks, and the Platosomia, Skates, and Rays, and (3) the Cyclostomia, with two subfamilies, the Lampredia and the Myxinia. As in case of Duméril's Chismopnés, the future of Rafinesque's Chismopnea depended wholly on his Chimeria.

Cuvier, 1817, again made a more exact separation of the Chondropterygii and the bony fishes, in which Rafinesque's Chismopnea were widely scattered; the Balistia became Plectognathes (Plectognatha Latr., 1825, Plectognathi Bonap., 1831), the Lophidia became Acanthopterygiens, the Meiopteria became Malacoptérygiens apodes, and the Chimeria were placed in the Chondroptérygiens a branchies fixes under Les Chimères. The two genera Chimaera and Callorhynchus were accepted by Cuvier. His changes notwithstanding, the order Chismopnea still existed by virtue of the Chimaeroids contained in it.

Latreille, 1825, made use of the name Ichthyodera for his third class, Cuvier's Chondroptérygiens a branchies fixes, placing in this class two orders, the first, Selacii, Duméril's Plagiostomes, with three families, the Squalides, the Platysoma, and the Acanthorhina (Chimaerae), and the second, Cyclostoma, with two families, the Aulocdibranchia (Petromyzonidae) and the Diporobranchia (Myxinidae). The name Acanthorhina cannot be looked upon as particularly appropriate since Blainville, 1816, had used Acanthorhinus for Spinacoid sharks.

Bonaparte, 1831, subdivided his subclass Chondropterygii into Section 1 Chismopnei (Branchiati) and Section 2, Trematopnei (Spiraculati). In the first he placed his order 6, Eleutheropomi (Sturiones), Family 32, Acipenseridae, and his order 7, Acanthorrhini, Family 33, Chimaeridae; and in the second

he put his order 8, Plagiostomi (Selacii), Family 34, Squalidae, and Family 35, Rajidae, and his order 9, Cyclostomi, Family 36, Petromyzonidae. The same objections apply in the case of his order Acanthorrhini as in that of Latreille's, Family Acanthorhina.

Müller, 1834–35, settled the question of priority so far as concerned him by a name of his own, Holocephala. He included in this order only Thienemann's 1828, Family Chimaerae, Bonaparte's, 1831, Chimaeridae, containing the two genera discovered in 1754. The new name was supposed to be more appropriate for these Chondropterygii on account of the suspensorial connections of the lower jaws. However, if it be taken into consideration that the rostral cartilages of the Antacea, Sharks, and of the Platosomia, Skates and Rays, are outgrowths of the skull, and not articulated to it, while the same cartilages of the Chimaeroids are articulations, and not solid outgrowths from the skull, it will appear that the term Holocephala would be quite as appropriate for Plagiostomia as for Chismopnea.

The living Chimaeroids may be classified as below.

CHISMOPNEA Raf., 1815.

Chismopnés Dum., 1806.
Holocephala Müll., 1834.

Chondropterygii, with a compressed and massive body, an attenuated caudal region, a single external branchial cleft on each side, an erectile first dorsal spine and fin, a cartilaginous skeleton, a notochord not divided in vertebrae, a brain in which the hemispheres are remote from the optic lobes, a rostrum of which the cartilages are articulated to the skull, a dentition of two pairs of upper and one pair of lower dental plates, a frontal tenaculum, ventral tenacula and claspers on the male, and without distinct suspensorial cartilages for the lower jaws, without shagreen on the skin and without a diverticular gland on the intestine. Oviparous, the egg deposited in a horny case.

RHINOCHIMAERIDAE Garm., 1901.

Chismopnea, with an elongate, pointed, movable proboscis, with olfactory bulbs and hemispheres of the brain remote from one another, with a notochord surrounded by narrow cartilaginous rings, with a simple cartilage in each clasper of the male, and with subtubular lateral canals opening outward through a narrow slit. At present this family contains two genera of a single species each.

Species with compressed proboscis and having teeth with cutting edges and without tritors on the sides of the plates.

Rhinochimaera pacifica Mits.; Garm., 1901.

Species with depressed proboscis and with palatine and mandibular teeth bearing numerous tritors in several series on the sides of the plates.

Harriotta raleighana Goode & Bean, 1894.

CALLORHYNCHIDAE Garm., 1901.

Chismopnea, with a short proboscis ending in a retrorse leaf-shaped extremity, with palatine and mandibular teeth bearing one or two large tritors on the side of each plate, with a notochord not surrounded by narrow cartilaginous rings, with a simple cartilage in each clasper of the male, and with lateral canals that in the adult become tubular, opening outward through pores. Only one genus now known.

CALLORHYNCHUS Gronow, 1754, 1763.

From the teeth of the specimens at hand five species are to be distinguished.

Callorhynchus callorhynchus Linnè, 1758.
Callorhynchus milii Bory, 1823.
Callorhynchus smythii Benn., 1839.
Callorhynchus capensis Dum., 1865.
Callorhynchus tritoris Garm.

Callorhynchus antarcticus La C., *C. australis* Shaw, and *C. peronii* Dum. appear to be synonyms for *C. callorhynchus*. *Callorhynchus tasmanius* Rich. is not to be separated from *C. milii*. Dr. Filippi, 1892, described two species without giving the dental characters; one of these, his *C. antarticus*, resembles *C. smythii*, the other is much like *C. callorhynchus*. Dr. Alcock, 1891, secured indications of the existence of another species from the Bay of Bengal; it was named *C. indicus* by Garman, 1899, from the horny egg case, and is probably to be found only at great depths. The fossil species *C. hectori* Newton, 1876, is to be placed with *C. capensis*, at least until more than the dentition is known about it.

CHIMAERIDAE Thien., 1828.

Chimaerae Thien., 1828.
Chimaeridae Bonap., 1831.

Chismopnea without a proboscis, with tritors situated anteriorly on the edges of all the dental plates, with hemispheres and olfactory bulbs of the brain in contact, with a notochord surrounded by narrow cartilaginous rings, with a trifid cartilage in each clasper of the male, and with sulcate lateral canals.

CHIMAERA Linné, 1754, 1758.

Six living species of this genus are recognized.

Chimaera monstrosa Linné, 1754, 1758.
Chimaera phantasma Jordan & Snyder, 1900.
Chimaera affinis Capello, 1868.
Chimaera colliei Lay & Bennett, 1839.
Chimaera ogilbyi Waite, 1898.
Chimaera mitsukurii (Dean) Jordan & Snyder, 1904.

The synonymy of *Chimaera monstrosa* includes *C. argentea* Ascan., 1772, *C. borealis* Shaw, 1804, *C. mediterranea* Risso, 1826, *C. cristata* Faber, 1829, and *Callorhynchus centrina* and *Call. atlantica* of Gronow and Gray, 1854; and that of *Chimaera affinis* contains *C. plumbea* Gill, 1877, and *C. abbreviata* Gill, 1883.

Chimaera monstrosa and *C. phantasma* have the anal fin distinct from the subcaudal; they differ in this respect from the other species. One of the latter, *C. colliei*, has been made the type of a new genus, *Hydrolagus*, by Gill, 1862. This genus was originally "distinguished from Chimaera by the absence of an anal fin and the triple division of the sexual organ of the male." The absence of the triple division of the clasper is more apparent than real, since the cartilage of that organ is trifid in males of all the species of the genus. On *Chimaera colliei* two of the divisions of the cartilage are wrapped together by the skin so as to present the appearance of a single division. If absence of the anal fin is to make generic separation necessary, then *Chimaera affinis* would be placed with *C. colliei*, though actually farther removed by structure from the latter than *C. monstrosa*. As may be seen by comparison of the figures published here, in dental characters and in those of the brain and the skeleton *Chimaera colliei* agrees closely with *C. monstrosa*. In some respects *Chimaera mitsukurii* accords with *C. colliei*, as in the apparently bifid claspers and the lack of an anal fin, but it has a much longer caudal filament than that species.

The right of Chimaera to be considered the most differentiated of the Chismopnea will hardly be questioned. By rostrum, dentition, brain, claspers, and lateral system it is the farthest removed from Rhinochimaera.